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/ NATIONAL BUREAU OF STANDARDS

# Technical News Bulletin

UNITED  
STATES  
DEPARTMENT  
OF  
COMMERCE



NATIONAL BUREAU OF STANDARDS

# Technical News Bulletin

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- 291 Phase Transitions in Cesium Lead Chloride
- 292 Synthesis of Organo-Derivatives of Transition Elements
- 294 Evaluation of Strength Test Method for Ceramic Substrates
- 295 Elevator Safety Code Revised
- 296 Systems Analysis Aids in Urban Problem Areas
- 298 An Industry's Response to New-State-Standards Program
- 300 Directional Coupler Design
- 303 Standards and Calibration
- 304 Optical Radiation News
- 305 Standard Reference Materials
- 306 NSRDS News
- 308 Publications
- 310 Index to the *Technical News Bulletin*—Vol. 55, 1971

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COVER: R. D. Young of the Optical Physics Division is using a field emission probe to measure the microtopography of replicas of diffraction gratings. Here a portion of the apparatus is superimposed over a topographic map of an infrared grating. Vertical displacements as small as 30 Å (or 3 nm) are resolved with this technique. Individual scans of the probe are approximately 800 Å apart.

## U.S. DEPARTMENT OF COMMERCE Maurice H. Stans, Secretary

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Assistant Secretary  
for Science and Technology

NATIONAL BUREAU OF STANDARDS  
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The Institute for Materials Research

The Institute for Applied Technology

Center for Radiation Research

Center for Computer Sciences and Technology

The TECHNICAL NEWS BULLETIN is published to keep science and industry informed regarding the technical programs, accomplishments, and activities of NBS.

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# Phase Transitions in Cesium Lead Chloride

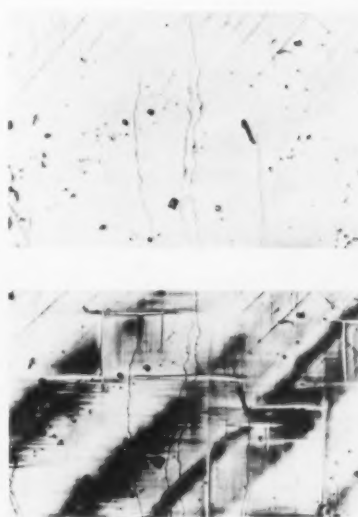
INVESTIGATIONS AT NBS HAVE YIELDED SOME VALUABLE INFORMATION about a relatively uncharacterized material. M. I. Cohen, K. F. Young, Te-Tse Chang and W. S. Brower, Jr., of the Inorganic Materials Division, measured accurately the temperatures at which five phase changes occur in cesium lead chloride ( $\text{CsPbCl}_3$ ).<sup>1</sup> These phase transitions are extremely small, involving changes of interatomic distances on the order of a few hundredths of a percent. Such small variations are difficult or impossible to determine by means of x-ray diffraction. The NBS investigation was prompted by a discrepancy in literature data indicating the possibility that  $\text{CsPbCl}_3$  might have ferroelectric properties, thus perhaps making it useful in a variety of electronic applications. The accurate NBS measurements of the five phase transitions have now proven that  $\text{CsPbCl}_3$  has centrosymmetric symmetry at room temperature and only becomes noncentrosymmetric below 194 K.

The Bureau team detected the phase transitions in  $\text{CsPbCl}_3$  using electron paramagnetic resonance (EPR) techniques, differential thermal analysis (DTA), and dielectric measurements. The EPR method was applied to a gadolinium-doped  $\text{CsPbCl}_3$  crystal in which the gadolinium was used as a probe of the crystalline symmetry. In this technique<sup>2</sup> the absorption of microwave power is observed when the magnetic ion undergoes transitions between different energy states within a magnetic field. The number and separation of such

energy states depends on the symmetry of the crystalline field. As a function of increasing magnetic field different transitions will become resonant and hence an absorption spectrum will be observed.

In the highest symmetry form (cubic) the gadolinium shows its simplest spectrum of seven lines. By decreasing the temperature, the first phase transition appears at 319 K and increases the spectrum to 13 lines. Subsequent lowering of the temperature has shown four more phase transitions at 315, 310, 194, and 176 K. Some of these structure changes were also observable by other techniques. Phase transitions are known to be either endothermic or exothermic in nature; that is, the crystal either absorbs or emits heat during a transition. The DTA method graphically notes the thermal differential variation between the sample and a thermally inert reference material, as the sample and reference are heated at a linear rate. The differential thermal analysis was done on undoped  $\text{CsPbCl}_3$  with commercially produced, highly sensitive instruments. Anomalous effects in differential temperature plots verified two of the higher temperature phase transitions using these methods.

The dielectric constant of cesium lead chloride was measured by recording the capacitance of a known parallel-plate capacitor, then substituting a  $\text{CsPbCl}_3$  sample for the known dielectric between the plates. The capacitor was suspended in a cylindrical cell which could be filled with exchange gas or evacuated; the cell was then immersed in an isothermal bath for



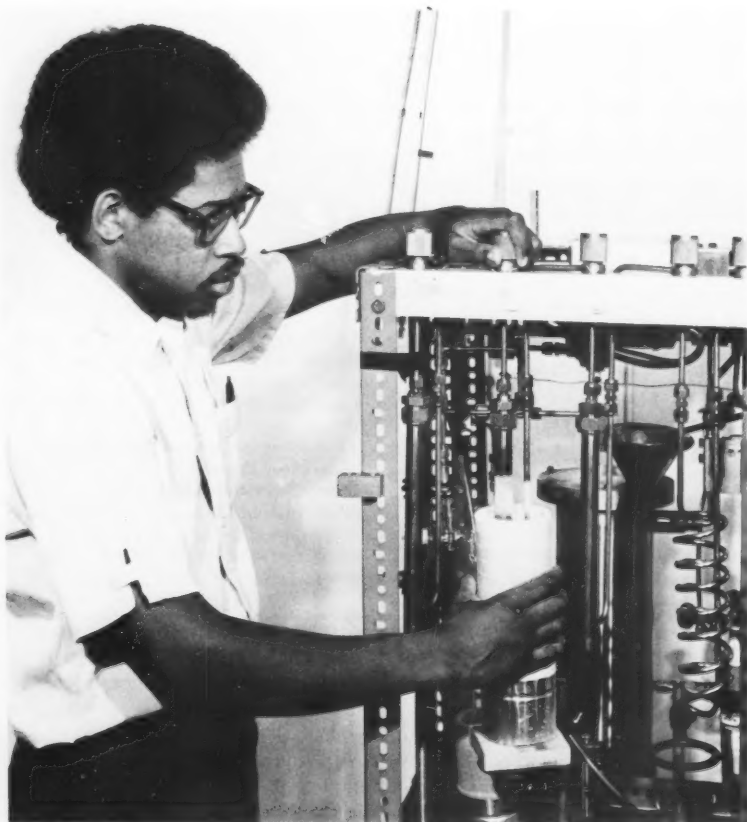
*Cesium lead chloride undergoes five phase transitions in the temperature range 70 to 325 K. A photomicrograph of the crystal (top) shows no transformations, only surface defects and distinct cleavage lines that lie along planes of the crystal. The bottom photo shows the same section of the crystal after transformation illustrating two twinning deformations: one set, following the orientation of the cleavage planes, and another set at 45 degrees to the cleavage planes.*

determining dielectric constants at various temperatures. In general, over the temperature range of interest, the dielectric constant of  $\text{CsPbCl}_3$  showed smaller increases with increasing temperature than expected. Therefore, if the material is ferroelectric at all, it appears at temperatures that are too low to be useful for scientific or engineering purposes.

<sup>1</sup> For further details, see Cohen, M. I., Young, K. F., Chang, Te-Tse, and Brower, W. S., Jr., Phase transitions in  $\text{CsPbCl}_3$ , *J. Appl. Phys.* to be published Dec. 1971.

<sup>2</sup> Versatile probe for optical-EPR studies, *Nat. Bur. Stand. (U.S.)*, Tech. News Bull. 53, No. 2, 30-31 (Feb. 1969).

# SYNTHESIS OF ORGANO-DERIVATIVES OF TRANSITION ELEMENTS



The marked volatility of many of the transition metal halides in their highest oxidation state requires most manipulations to be carried out in high vacuum systems, thereby minimizing contamination of either the sample or the laboratory atmosphere. These highly reactive metal halides are most conveniently handled in greaseless all-metal vacuum lines. Here Kenneth Jewett, research chemist, is separating tungsten hexafluoride from a less volatile reaction product. The stainless steel vacuum line pictured has been used extensively for synthesis involving both tungsten and molybdenum hexafluorides.

SYNTHETIC PROCEDURES DEVELOPED BY BUREAU CHEMISTS have led to the preparation of several families of new compounds of tungsten in its highest oxidation state. The NBS techniques overcome complications from oxidation-reduction reactions that have been common in synthetic work on high-valent tungsten compounds and may provide general methods for rational synthesis of organo-derivatives of the transition elements in their highest oxidation states.

The generality of the approach offers a prospect for developing an extensive, rational chemistry of the transition elements in their high oxidation states. Through better understanding of their chemical behavior, more effective technological utilization of these elements is a definite prospect. One possible application of this work, for example, is the use of new reaction procedures to introduce heavy elements into organic materials to enhance such properties as flame retardancy.

During the past decade much effort has been devoted to developing the synthetic chemistry of tungsten, particularly the chemistry of low-valency organotransition metal derivatives. The NBS work has emphasized preparative chemistry of tungsten in the +6 state, and, in essence, involves the transfer of

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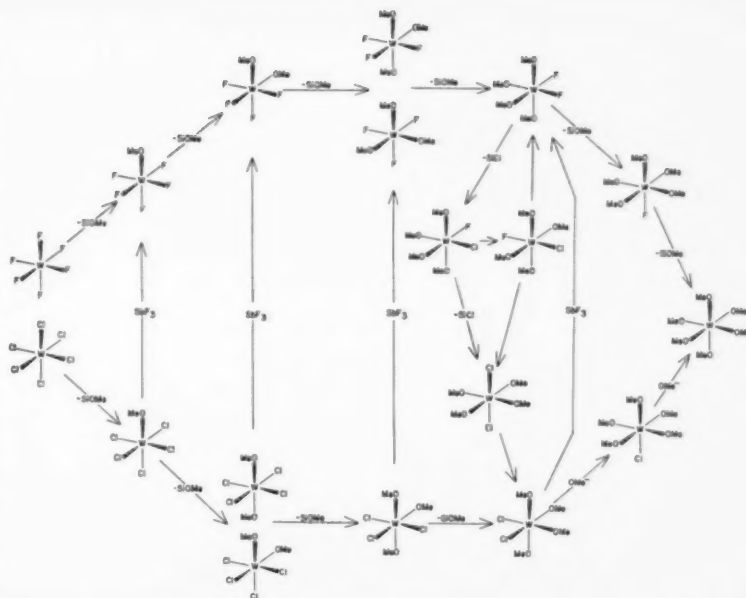


techniques and reagents useful in the chemistry of the main-group elements to problems of transition-metal chemistry. Using this approach, Dr. F. E. Brinckman, in collaboration with Dr. L. B. Handy,\* a Postdoctoral Research Associate, successfully prepared for the first time the series of methoxytungsten(VI) fluorides (compounds of the formula  $(\text{CH}_3\text{O})_x \text{WF}_{6-x}$ ).<sup>1</sup> Along with another Postdoctoral, Dr. K. G. Sharp,\*\* and Mr. K. L. Jewett, they have extended this work to a variety of other tungsten compounds.

The technique employed in the early stages of the synthetic work involves the use of readily available organosilanes, which react with tungsten(VI) halides under homogeneous conditions in inert solvents to transfer groups or ligands from silicon to tungsten. One example of this substitution reaction involves the reaction of tungsten hexafluoride with methoxytrimethylsilane,  $\text{CH}_3\text{OSi}(\text{CH}_3)_3$ . Through a series of controlled steps, one or more methoxy groups ( $\text{CH}_3\text{O}-$ ) can selectively replace fluorine atoms in the octahedral  $\text{WF}_6$  molecule. The extent of replacement can be controlled by adjusting the amount of silane reagent used.

A similar approach has been used to prepare the corresponding series of methoxytungsten(VI) chlorides.<sup>2</sup> The new compounds demonstrated greater stability than the parent hexafluoride and hexachloride and may, themselves, be used as starting points for syntheses of still other tungsten derivatives. A variety of silicon compounds can be used in these reactions, permitting substitution of groups such as halide, cyanide, and isocyanate onto the tungsten atom.<sup>3</sup>

The procedure using silane reagents avoids complications from oxidation-reduction reactions that are frequently encountered in work



The reaction flow chart summarizes some of the new compounds and reactions studied. Starting with either  $\text{WCl}_6$  or  $\text{WF}_6$ , at the left, the procedures developed permit substitution of methoxy groups for halogen atoms in a stepwise fashion. Complete substitution by either pathway leads to the hexamethoxy compound shown at right. The geometric structures of each compound have been determined from NMR spectroscopy. In cases where more than one structure is possible, both may occur or a single isomer may be preferred. Individual members of the chloride and fluoride series may be interconverted as shown. These processes occur stereospecifically.

on high-valent tungsten. Organic ligands or groups are often reducing in the presence of a strongly oxidizing species such as tungsten(VI). However, the stabilization provided by the NBS procedure allows preparation of the desired products in high yields and excellent purity. This technique requires the use of high-vacuum systems and inert-atmosphere chambers because of the volatility and toxicity of the tungsten fluorides and the sensitivity of some of the compounds to air and moisture.

The geometric configuration of the new compounds has been established by nuclear magnetic resonance spectroscopy. NMR studies carried out by Dr. R. Johansen show that *cis* isomers often predominate, although *trans* geometry can become important for systems involving groups other than fluorine or methoxy. The NMR

work has also allowed development of structural correlations which greatly facilitates the task of assigning geometrical configurations to new compounds. As new materials of known stereochemistry become available, assessment of the effects of ligands on geometry and on the detailed steric course of the displacement reactions will be possible. Because of the large array of stereoisomers possible, an evaluation can be made of the relative contributions of steric and electronic effects to the stability of metals in their highest oxidation states.

<sup>1</sup> Handy, L. B., and Brinckman, F. E., Chemistry of the methoxyfluorotungsten (VI) series, Chem. Comm., 214 (1970).

<sup>2</sup> Handy, L. B., Sharp, K. G., and Brinckman, F. E., The metathetical chemistry of halotungsten (VI) compounds: synthesis and geometry of organoxy fluorides and chlorides, Inorg. Chem., in press.

<sup>3</sup> Brinckman, F. E., Jewett, K. L., and Handy, L. B., NMR studies on the redistribution of halides and pseudo-halides between *cis-tetakis* (methoxy) tungsten(VI) dihalides and organosilanes, Abstracts of Papers, XXIII IUPAC, Boston, Mass., July 1971, p. 78.

\*Now with the University of Arkansas, Fayetteville.

\*\*Now with the University of Southern California, Los Angeles.

# EVALUATION OF STRENGTH TEST METHOD FOR CERAMIC SUBSTRATES

J. B. WACHTMAN, JR., W. CAPPS AND J. MANDEL<sup>1</sup> OF THE INSTITUTE FOR MATERIALS RESEARCH headed an interlaboratory evaluation of a biaxial flexure strength test method for polycrystalline alumina ceramics. The purpose of the round robin was to determine the suitability of this test method for measuring the strength of thin, circular disks of brittle materials and to define the standard deviation among and within laboratories. The results show a coefficient of variation of about 7% within a laboratory with only a small increase in variability for interlaboratory comparisons. The lab-to-lab variation appears to be sufficiently small that the test can provide an accurate means for comparison of strengths measured in different laboratories. Developed in an effort to meet a need of the ceramic industry and to respond to concern stated by a committee of the American Society for Testing and Materials, the test method has been proposed to ASTM as a possible standard.

The test method, based on a stress analysis by A. Kirstein of NBS, involved the design and construction of a novel sample holding and loading fixture to be used with laboratory compression-type test machines. Preliminary evaluations of the new technique using commercially prepared substrate specimens were conducted at NBS; the findings were compared with results of similar material prepared and tested according to specifica-

tions of the Alumina Manufacturers Association's "microbar" flexure test method. Favorable reaction to the comparison prompted the interlaboratory study.

Polycrystalline ceramic substrates form the basis for an important family of electronic devices by providing an inexpensive, strong, dimensionally stable insulator capable of being produced with acceptable surface finish and heat dissipation ability. An accurate and practical test method for the measurement of strength of ceramic substrates is desirable for several reasons. A reproducible technique is important in setting and controlling strength specifications in production. Such a method would aid in the development of substrate technology—providing a means whereby changes in materials or processing could be evaluated. It would also enable researchers to study such strength-controlling factors as microstructure, surface condition, and environment. Fracture in brittle materials frequently originates at a surface and the strength is determined by surface condition in conjunction with internal microstructure rather than by internal microstructure alone. A useful test method should permit the determination of strength of specimens having the same surface condition as they have in use.

The most popular test method in current use, a beam-bending method, requires lath-shaped specimens which either must be ground to certain dimensions and surface

finish or must be cut from larger specimens forming raw edges. Either procedure can mask the desired results.

The biaxial flexure test method developed at NBS—the "Piston-on-3-ball" technique—involves supporting a plate on three balls equidistant from its center and uniformly loading a small, circular central area. The area of maximum tensile stress thus falls at the center of the lower face of the plate and the strength should be independent of the condition of the edges of the plate. This method has been accurately analyzed for small deflections (less than one-half the specimen thickness). The technique of supporting the specimen on three balls allows the use of a slightly warped specimen; thus no surface grinding or polishing is required. This makes it possible to test ceramic plates with an as-fired surface finish.

Eleven laboratories constructed their own test jigs according to the design developed by NBS. A total of eight types of polycrystalline alumina substrates, chosen to represent different strength levels, were supplied by five manufacturers. Strength variations ranged from 46 to 96 kpsi ( $3.2$  to  $6.6 \times 10^3$  N/m<sup>2</sup>). Each laboratory was supplied with a randomized selection of specimens together with a random order of testing for 10 specimens of each substrate. The purpose of this randomization was to eliminate time effects. Samples were cleaned and dried; the relative humidity of the air was recorded; and the samples

tested in the randomized order specified. Each laboratory recorded the diameter of each specimen, its thickness adjacent to the origin of fracture, and the breaking load. The breaking strength values were calculated using a Poisson's ratio value of 0.23. The results and the specimens (the fragments from each specimen were placed in individual envelopes) were then returned to NBS.

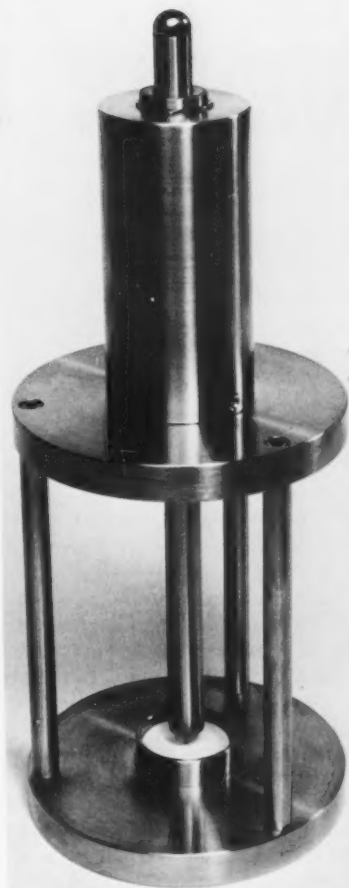
The results from 11 laboratories were examined by fitting least squares straight lines to their data and examining the resulting lines for indications of systematic differences between the laboratories. Small systematic differences are detectable but are so much less than the scatter within each laboratory that the most significant factor contributing to scatter in the data appears to be variations in the material. Examination of the data for all materials shows that, although there is always an increase in the standard deviation when the variation between laboratories is included, it is always small compared to the variation within laboratories. For example, the standard deviation within the laboratories of the substrate with an average strength of 46 kpsi was 3.7 kpsi. When the lab-to-lab variation was included the

*The loading jig developed for testing polycrystalline alumina ceramics is shown with a test specimen in place. Test specimens 1.25 inches in diameter and .025—.060 inch thick were evaluated.*

standard deviation increased only to 4.7 kpsi. This is an important finding for the purposes of evaluating the piston-on-3-ball test as a practical field test for the strength of ceramic substrates.

The data were also analyzed to determine the number of measurements required to give a reasonable measure of average strength. The coefficients of variation (the ratio of the standard deviation to the average strength) were determined for single and for averages of five and 10 replicate measurements per laboratory. Results using a single measurement vary from 10.3 to 14.5%. The coefficients of variation for averages of five measurements range from 6.5 to 7.6%. For averages of ten measurements the range is 5.2 to 6.8%. These results suggest that while an average of 10 measurements is somewhat preferable, an average based on five measurements by each laboratory is nearly as good and may be sufficient for practical testing.

<sup>1</sup> Wachtman, J. B., Jr., Capps, W., and Mandel, J., Biaxial flexure testing of ceramic substrates, ASTM Materials Research and Standards, in press.



## ELEVATOR SAFETY CODE REVISED

A new (8th) edition, the first in 6 years, of the American National Standard Safety Code for Elevators, Dumbwaiters, Escalators, and Moving Walks (ANSI A17.1-1971) has been published by the ASME.<sup>1</sup> This edition incorporates the revisions covered by supplements A17.1a-1967, A17.1b-1968, and A17.1c-1969, and A17.1d-1970 plus 94 revisions or additions that were approved by the Standard Committee,

the Secretariats (including NBS), and (on July 27, 1971) the American National Standards Institute.

The Code is intended to serve as a guide for state and municipal authorities in drafting regulations governing the installation and maintenance of elevators, dumbwaiters, private residence inclined lifts, escalators, and moving walks. It is also intended as a standard reference on safety requirements

for architects, engineers, casualty insurance companies, and manufacturers, and as a standard of practice for owners and managers of structures where equipment under the scope of this Code is used.

<sup>1</sup> Available from The American Society of Mechanical Engineers, United Engineering Center, 345 East 45th Street, New York, N.Y. 10017. Price \$11.75 per copy (\$9.40 to ASME members), 30% discount on all orders of 100 or more.

# SYSTEMS ANALYSIS AIDS IN URBAN PROBLEM AREAS

THE PROBLEMS BESETTING OUR NATION'S CITIES ARE KNOWN TO ALL. Less well known is the fact that the Bureau is cooperating with other government agencies in finding solutions to the problems of urban life. Included in this work are operations research, systems analysis, and cost-effectiveness studies performed by the Technical Analysis Division since 1965. Bureau involvement is often under the sponsorship of such Federal agencies as the Department of Housing and Urban Development (HUD) and the Department of Health, Education, and Welfare (HEW).

TAD uses analysts, mathematicians, economists, psychologists, engineers, sociologists, lawyers, computer specialists, and anthropologists in meeting the needs of its clients. These specialists have worked in transportation research, city planning, communications, education, environmental quality, and human factors—all areas of interest to municipal authorities and urban planners. TAD's staff makes frequent use of computer-operated models and has performed tasks ranging from making a model simulating the women's nylon hosiery industry to evaluating employee performance in using mail-sorting equipment. Following are examples

of TAD contributions to understanding urban problems.

## URBAN INFORMATION SYSTEM

TAD supplied technical assistance for and acted as a consultant and analyst to HUD's Urban Information Systems Interagency Committee, which operated an urban information system that included six municipalities. Each of the cities set up and operated its own municipal information system, each composed of subsystems devoted to such areas as public safety, finances, developing human resources, and physical and economic development of the city.

The operation of this experimental system produced a wealth of useful data on such systems—data base management summaries and selection criteria, system requirements, the compatibility of COBOL with the other compiler languages used, proprietary software constraints, and the transferability of data between systems. TAD is now analyzing these data and evaluating the system.

## PLANNING FOR PUBLIC FACILITIES

One of the more obvious uses of models in urban planning is in selecting sites for schools, playgrounds, transportation,

bridges, police stations, firehouses, and other such municipal facilities. This is done, as in the case of firehouse planning, by breaking up each street of the city into links separated by nodes and characterized by length, allowable direction (for one-way streets), and speed limit. Each structure within the service area could then be defined by intersections of links enclosing it, height, construction type, age, and area per floor. Analyses of past fires are added in computing susceptibility of each structure to fire. The running time from the firehouse during given traffic conditions (including time penalties for congested intersections) is known. All this information is placed in the computer, which then determines the optimum set of fire station locations.

TAD was asked to assist East Lansing, Mich., in selecting the best location for fire stations in that city. TAD served as a technical coach to the city's own staff in using the described techniques and in developing a simulation model that projected fire protection for years in the future. This study clearly showed that the fire station on the Michigan State University campus should remain there, that the present East Lansing municipal station should be moved to a new site



northwest of its downtown location, and that a third station should be built to serve the southeast portion of the city. This project demonstrated that the professional staff of a city faced with such a decision can, with some assistance, similarly apply the techniques of systems analysis to obtain the optimum solution.

A similar project was to set up a plan for ambulance service in Fairfax County, Va., such that response time (running time from depot to patient, plus picking up the patient, plus running time to the nearest hospital) would not exceed a specified maximum. The TAD analysts set up a model of this system. It showed graphically the output as a cost-benefit curve giving the number of ambulances that would fully serve the area for a series of maximum response times.

#### SITING AIR POLLUTION SAMPLERS

The National Air Sampling Network (NASN), which has grown with increased awareness of the consequences of pollution, in 1967 began accepting data from more than one site in some communities. This brought about the question: What is the best way to select locations for several pollution samplers in the same city? TAD was asked by the Division of Air Quality and Emission Data of the National Air Pollution Control Administration (NAPCA) to establish procedures for selecting the sites that would result in gathering data of the greatest possible significance.<sup>1</sup>

TAD and NAPCA personnel working on this project developed a set of procedures for the selection and experimentally applied them to an Air Quality Control Region. The model weighted the actual pollutant concentrations found by the relative population to appraise the total consequences of the pollution; the population factor could be chosen to represent populations of the future.

*Continued on page 302*



*George Walsh, of the District of Columbia Air Pollution Division, transcribes pollution data at a sampling station. Recent Bureau work describes how to select the best sites for the installation of such apparatus.*



*Choosing the locations of new firehouses for best response is simplified by use of systems analysis techniques.*

# AN INDUSTRY'S RESPONSE TO NEW-STATE-STANDARDS PROGRAM

MINNESOTA RECEIVED A NEW SET OF WEIGHTS AND MEASURES STANDARDS at a ceremony held in Minneapolis on August 24, 1971. The standards, plus supporting equipment, were presented to the State by Lawrence M. Kushner, Deputy Director of the Bureau, and accepted by State Attorney General Warren Spannaus at the State Weights and Measures Laboratory in Minneapolis.

This marked the 29th State that has formally received the new standards package in the program being conducted by the Office of Weights and Measures. The goal of the State-Standards Program is to provide each of the 50 States with new standards so that each can respond to the weights and measures needs in everyday commerce. The needs for and the benefits of the program are perhaps best described in the accompanying excerpts from a speech given by Kenneth S. Jensen of the 3M Co. speaking on behalf of industry at the dedication ceremony.

"It is a singular privilege for 3M Company to have been asked to participate in this program of presentation and acceptance of these standards by the National Bureau of Standards to the State of Minnesota.

"As is the case with other firms whose products compete in the market—it is imperative that our customers be assured that these products are fairly and accurately described. It is critically important to the customer that he or she has confidence that the weight of the material in the box of goods or the can of fluid purchased is, in fact,

that which is stated on the container label. It is equally critical to the manufacturer that the same conditions hold. The customer has a right to expect that the product will be at least as much as specified and would prefer that it exceed the amount designated. The manufacturer recognizes that he has an obligation to meet the specified quantity for there are few things which cause greater dissatisfaction to a consumer than to believe he has not received true measure for his purchase. A single dissatisfied customer is not to be reckoned with lightly, for despite the advertising dollars spent in promoting a product, that customer has friends, acquaintances and relatives who, generally speaking, have much more confidence in his personal experience than in any other published or spoken word. It is no longer then a matter of a single customer, but the effect is felt over a much broader spectrum of potential customers.

"The manufacturer has an additional constraint if he is to be successful. This constraint is one of competition with others who make similar products and compete for the customer's favor. These competitive forces do not allow a manufacturer to consistently put a lot more in the package than is specified on the label, for if he does a distinct loss of profit is incurred; a profit which is necessary in support of his research and development programs for improving that product or other new products and services, money which allows him to pay the wages of the additional personnel who may be needed to

support those programs which have not yet reached the market place.

"Therefore, the manufacturer in the real proving ground of success, the market place, is vitally concerned with the units of measurement. How much does it weigh, how long is it, what is the volume—all critical, for they help determine customer satisfaction and company prosperity.

"Even before a product reaches the market place, the manufacturer is vitally concerned with these units. The laboratory which may conceive a new product formulation can pass this formulation along to the pilot plant for small scale evaluation only if the units of measurement are well defined. The laboratory quantity may be but a few hundred milliliters or fluid ounces, if you prefer, and from the individual components which may weigh only milligrams the pilot plant attempts to scale the process up to kilogram level. Each group must know that the standards of mass and volume they use are consistent in order that the scale-up can be effective.

"The pilot plant, in turn, must be assured that the units it specifies for production quantities are consistent with those of the manufacturing plant which may be located within the State or in another State so that the end product is what was intended back at the laboratory stage.

"From product conception to consumption, a common thread runs throughout. That thread is consistency of measure whether we talk about minute quantities at the laboratory level or freight car quan-

tity at the production level or aerosol can quantity at the consumer level. That same thread must relate these quantities whether we are transferring the material from one laboratory to another, from one state to another and in our multinational company, from one country to another. How very critical it is, the standard by which these quantities have been measured. In the limit this consistency has transcended purely company boundaries and has encompassed international boundaries.

"Our country, through international standard organizations, has established the relationship of our national standards with those of other participating countries. Our various State legislatures have passed those laws necessary to assure uniformity between them and the national units. That this consistency be maintained and placed in even closer agreement is a particular purpose of the dedication here today; for the standards presented and accepted are the physical representation of that requirement for consistency.

"Obviously, it is impractical for all industries to submit their total production volume to a single standardization laboratory such as the Minnesota Weights and Measures Division for determination of weight or length or volume. Industry must have its own local standards by which product quantity or size is established. In order that the relationship between their standards and the legal standards can be ascertained is one of the purposes for which laboratories such as the National Bureau of Standards and the Minnesota Weights and Measures Division have been established. Our firm on a regular and consistent basis, submits our local standards, which are the best available today, to these recognized laboratories for certification. As examples, the weights used to check our truck scales down to the



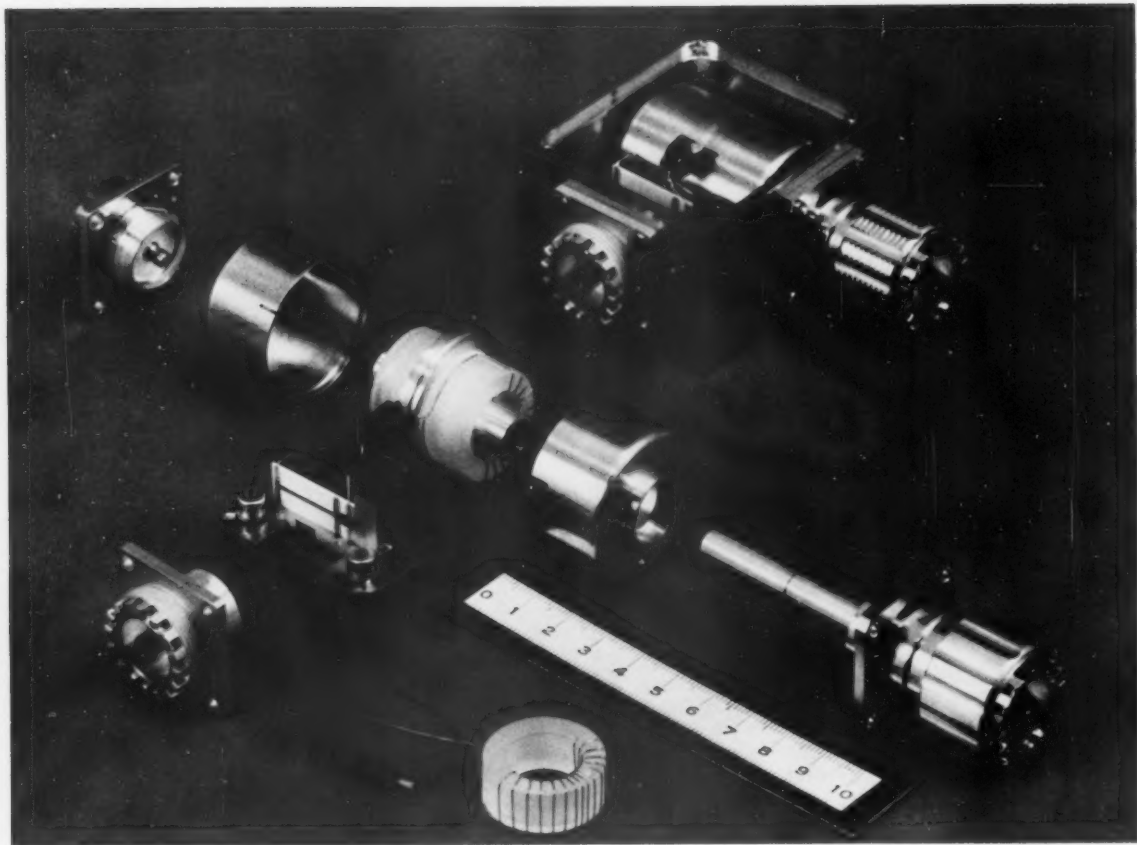
*This 30 kg mass standard is part of the package provided by NBS in the program to improve the measurement capabilities of state weights and measures laboratories. W. Gallagher of NBS, making a mass determination, can be seen in reflection from the top of the standard.*

weights used to check analytical balances in the laboratory are submitted to the Minnesota Weights and Measures Division. Other standards such as standard cell groups, standard resistors, platinum resistance thermometers and the like are submitted to the National Bureau of Standards. Periodically, these internal standards are intercompared in our own laboratory to help assure that between certifica-

tion by these recognized organizations that the standards are stable and can be depended upon to truly reflect consistency with the legal units. We are, therefore, truly concerned about units of measurement for they in turn affect the way in which our products are developed and sold.

"We feel fortunate that the improved facilities evidenced by these

*Continued on page 302*



*The directional coupler (top) and components used in its construction.*

## DIRECTIONAL COUPLER DESIGN

A BROADBAND, LUMPED-ELEMENT DIRECTIONAL COUPLER with unusually good characteristics has been developed at the NBS Boulder (Colorado) Laboratories. The work was carried out under a Department of Defense contract by C. A. Hoer. Used in coaxial radio-frequency transmission systems to measure various electrical quantities and parameters, the coupler combines high directivity and

power capability with constant coupling over a broad frequency range. It also has a very low standing wave ratio (SWR) at all ports.

The coupler's basic design can be modified to give optimum characteristics over large power and frequency ranges. Models have been constructed that have ranges of 0.1 to 30 MHz, 2 to 50 MHz, 10 to 300 MHz, and 5 to 400 MHz, with power capabilities up to 50 kW.

The coupler is used to measure the forward and reflected power, the impedance, the reflection coefficients, and the SWR of coaxial transmission lines, joints, and other components. Accurate evaluation of these parameters is essential to efficient design and operation of radio-frequency (rf) systems used in radio and television stations, defense and civilian communication systems and networks, radar, and in scien-

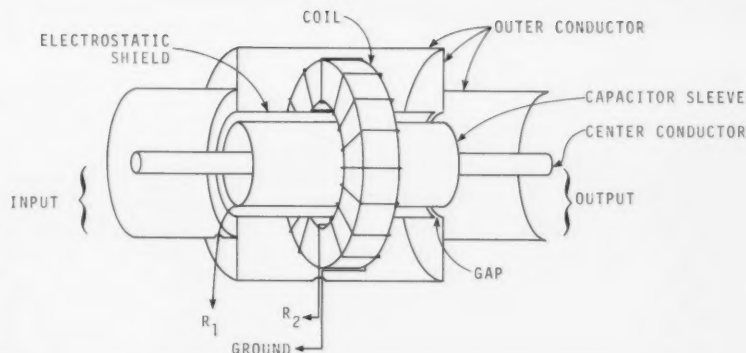


tific research, to name but a few of the possible areas of application of the device.

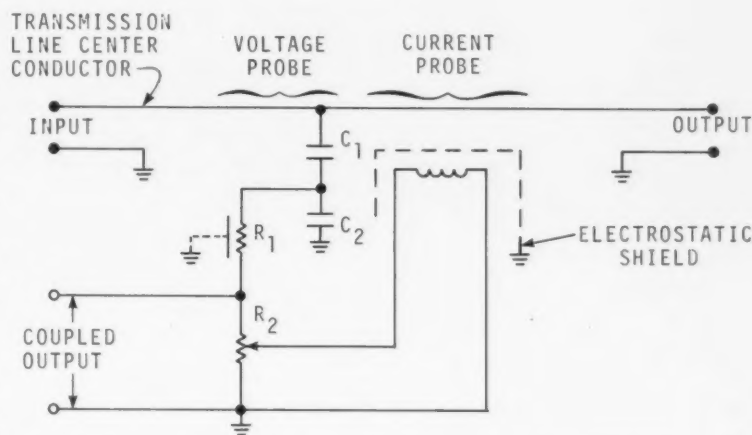
In lumped-element directional couplers, in contrast to the distributed-element couplers used with waveguide systems, the resistance, inductance and capacitance are lumped into discrete components rather than being distributed along the union between two waveguides.

Most lumped-element couplers can be regarded as two separate circuits: a voltage sampler and a current sampler. The outputs of these samplers are combined so that they add or subtract, depending on the direction of energy flow in the transmission line. Analysis of these outputs then provides information about the electrical characteristics of the circuit being tested. In the new device, the voltage sampler is a capacitive voltage divider connected to a resistive voltage divider. The capacitance may be discrete or distributed in the form of a metal sleeve around the main-line center conductor, depending on the power and frequency ranges. The current sampler is a toroidal coil concentric with the main-line center conductor. The coil is shielded from the center conductor so that it couples to the magnetic field but not to the electric field. The coil is connected across part of the resistive voltage divider to combine its output with that from the voltage sampler. The combined coupled output power is proportional to the power flowing in one direction or the other on the main line. Reversing the connections to the coil (or turning the coupler over) gives the power in the opposite direction, and once these powers are known, other characteristics of the system can be calculated.

The circuit has proved to be most useful for high power applications, with coupling ratios of 30 dB and higher. The circuit has been used to obtain coupling constant to within  $\pm 1.0$  dB over a 30:1 frequency range



Cross-sectional drawing of the new coupler. The gap breaks the current return path and allows magnetic coupling between the coil and the center conductor.



Schematic diagram of the improved directional coupler for measuring parameters of coaxial transmission lines.  $C_1$  and  $C_2$  are the capacitances from the sleeve to the center conductor and to ground, respectively. The distributed capacitance on  $R_1$  may be grounded or not, depending on the residual capacitances across  $R_1$ ,  $R_2$ , and to ground.

and high directivity (35 to 50 dB) over a 300:1 frequency range from 0.1 to 400 MHz. The SWR of all ports is less than 1.04 at those frequencies where the coupling is constant. These characteristics have been achieved at power levels up to 50 kW in 3-1/8-inch o.d. coaxial line. The performance of these couplers is a substantial improvement over existing designs, and the

physical size is considerably smaller than distributed-type couplers designed for the same frequencies.

A patent is pending on the design, and parties interested in producing models should contact Systems, Automation, and Instrumentation Section 272.55, National Bureau of Standards, Boulder, Colo. 80302; (303) 447-1000, ext. 3705 for information.

## URBAN PROBLEMS—continued

### PROJECT PHOENIX

TAD has been deeply involved for over a year on problems in the fire service area. This effort, called Project Phoenix, is funded by the NBS Office of Fire Research and Safety and the Department of Housing and Urban Development. Project Phoenix is concentrating on four problem areas: (1) resource allocation in fire departments, including equipment analysis, (2) fire statistical analysis, (3) management information systems, and (4) analysis of the interface between fire departments and the community.

Resource allocation analysis seeks to determine more efficient ways of doing given tasks and more effective means of reducing life hazard and property losses. In one effort fire station location models have been developed and are now being tested for a package of computer programs and manuals that cities can use to determine where to put fire stations. In another area,

Project Phoenix's equipment analysis will be useful to estimate more accurately the usefulness of a piece of equipment and to help decide whether to repair or replace a non-functioning piece of equipment.

The Bureau's fire statistical analysis program extends earlier work in study of the patterns of fires in space, time, and as correlated with socioeconomic data; analysis of firefighting effectiveness; and analysis of fire losses. Both a theoretical model and a statistical model are being formed to analyze fire behavior and fire department effectiveness. This task is expected to yield valuable information on the value of the minute in response time.

To manage a fire department, it is necessary to have information for planning and control purposes. Project Phoenix is developing management information systems (MIS) to help fire departments plan for future growth and to evaluate such things as the adequacy of fire prevention activities, the manning of companies, and equipment con-

figuration. In general, MIS is the vehicle for applying the resource allocation models. Members of the TAD staff are working with the city of Boston on applying resource allocation models there.

False alarms and firefighter harassment plague many fire departments and constitute a general problem for large cities. It is important, therefore, to analyze the causes and identify the programs that will remedy the situation. Workshops are being held across the country to identify promising programs and to appraise their effectiveness. A survey is now being planned to determine community attitudes toward fire departments. The output of this program is expected to shed some light on the seriousness of this problem and on the effectiveness of human relations, community relations, and public relations programs in reducing the problem.

<sup>1</sup> Siting air pollution samplers/NBS assists National Air Pollution Control Administration, Nat. Bur. Stand. (U.S.), Tech. News. Bull. 55, No. 11, 278-279 (Nov. 1971).

## INDUSTRY'S—continued

new standards, comparison apparatus and supporting equipment of the Minnesota Weights and Measures Division are available. One may tend to think of such laboratories as places where only routine measurements, which compare a local standard with a legal standard, is all that is accomplished, as important as that function may be. The Minnesota Weights and Measures Division has, however, undertaken other special work for which it has unique facilities, work which will greatly assist us in the development of a new standard gas mixture used to calibrate safety apparatus in areas of our laboratories and plant.

"The interdisciplinary nature of this development requires measurement of the highest level of con-

fidence in several fields. Our local facilities could cope with many of these through use of our standards which had previously been certified either at the National Bureau of Standards or at the Minnesota Weights and Measures Division. One critical measurement could not be done by us and that was the precise volumetric determination of a large closed cylinder. We needed to know the volume of this cylinder to within a few parts in ten thousand and no volumetric standard was available for a direct comparison.

"After discussing the problem with the Minnesota Weights and Measures Division, they agreed to attempt the determination. We are pleased that they were successful in this difficult measurement, one that many would not expect to be accomplished in a facility devoted in large part to certification of stand-

ards. If we are ultimately successful in the preparation and validation of this new gas standard, substantial credit is due the Minnesota Weights and Measures Division for their assistance.

"The dedication here today of these new and more precisely determined standards will provide all residents and industries within our State increased confidence that our basic units of measurement are consistent and accurate. We wish those responsible for the promulgation of these units throughout our State every success, for this is a field of endeavor which is technically difficult and whose purpose is not always understood by many of our citizens.

"On behalf of 3M Company I wish to thank you for the opportunity of presenting the industry response at this important occasion."



# STANDARDS AND CALIBRATION

## STANDARD FREQUENCY AND TIME BROADCASTS

### Broadcast of New Time Scale

Since 1967 the second has been defined in terms of an atomic transition, while time scales in general use are based on the rotation of the earth. This has resulted in the dissemination of a compromise time scale arrived at by international agreement through the International Radio Consultative Committee, and maintained by the International Bureau of Time (BIH). This scale, known as Coordinated Universal Time (UTC), presently operates with a frequency offset from the atomic scale of  $-300 \times 10^{-10}$  to approximately agree with the rotation of the earth. Occasional step adjustments in time of 0.1 second are also made to compensate for unpredictable variations in the earth's rate of rotation.

To avoid the disadvantages of having an offset frequency and fractional second step adjustments, the UTC time scale will change on 1 January 1972. The new UTC scale will operate with a frequency offset, thus providing time intervals that are exactly one second long. The scale will continue to keep in approximate agreement with earth time, known as UT1, by step adjustments of exactly one second occurring about once per year. There will be a preference of adjustments on the 1st of January and July. In any case the new UTC scale should not differ from UT1 by more than 0.7 second.

In the U.S., therefore, the NBS standard broadcast services of WWV, WWVH, and WWVL will be changed to have zero offsets in their

carrier and modulation frequencies; also, at 23 hours, 59 minutes, 60.107600 seconds (old UTC) on 31 December 1971, the new UTC scale will begin, reading 00 hours, 00 minutes, 00 seconds, 1 January 1972. This will make the new UTC scale 10 seconds late with respect to International Atomic Time (IAT) as maintained by the BIH.

Thereafter, the difference between UTC and IAT will always be an integral number of seconds. The difference between UT1 (not UT2) and the broadcast signal will also be given on the air after 1 January 1972, with a resolution of 0.1 second.

On WWVB, which presently operates with zero offset, the time scale will be reset by a different amount: at 23 hours, 59 minutes, 60.0452482 seconds (old SAT) on 31 December 1971, the new SAT scale will begin, reading 00 hours, 00 minutes, 00 seconds, 1 January 1972. This new SAT scale is the same as the new UTC scale, and thus is redundant. The WWVB time signals will henceforth be called UTC(NBS).

### TIME SIGNALS ON TELEPHONE

Time signals from the Bureau's radio station WWV can be heard on the telephone. By dialing (303) 499-7111, listeners can hear the accurate shortwave signals from Fort Collins, Colo., as received at the Bureau in Boulder, Colo. These signals are a national service provided by the U.S. Department of Commerce.

The signals include a voice announcement of Greenwich Mean Time (GMT) every minute, plus

standard audio-frequency tones and special announcements of interest to geophysicists and navigators. The time and frequency signals are the most accurate in the U.S. available to telephone users—callers from "the lower 48" should receive time signals accurate to within 30-40 milliseconds—and are controlled ultimately by the NBS Atomic Frequency Standard in Boulder.

Local time in the U.S. is derived from GMT by subtracting an appropriate number of hours. For instance, Mountain Daylight Time (MDT) is 6 hours earlier than GMT; 19 hours GMT is 13 hours MDT, or 1 p.m. The minutes and seconds are the same for GMT and local time. Thus, if you already know approximately what time it is, you only need to listen for the correct minute, and can omit calculating the hour. The time is given in the 24-hour system, where the hours from midnight to noon GMT are given the number 00 to 12, and from 1 p.m. to 11 p.m. GMT are given numbers from 13 to 23. Hence, 5:23 p.m. GMT would be given as 1723 GMT, or 17 hours, 23 minutes GMT.

In addition to the time and frequency signals, listeners may hear radio propagation forecasts for the North Atlantic region at 14 minutes past the hour, announcements of storm warnings for the North Atlantic Ocean at 16 minutes past, and geophysical alerts and notices of significant solar events, such as flares, eruptions, and proton showers at 18 minutes past.

Further information on station WWV may be had by contacting Frequency-Time Broadcast Services Section, National Bureau of Standards, Boulder, Colo. 80302.

# OPTICAL RADIATION NEWS

In many technical areas, including photometry, formal interaction among the various national laboratories takes place via the structure set up by the Treaty of the Meter, as described below. Such interaction between the national laboratories and industries in different countries, on the other hand, occurs in photometry via an independent organization, the International Commission on Illumination (Commission Internationale de l'Eclairage: CIE).

Responsibility for international physical standards rests with the General Conference of Weights and Measures (Conférence Générale des Poids et Mesures: CGPM). This large body, with representatives of many nations, normally meets every 6 years and acts on the technical recommendations of its executive body, the International Committee for Weights and Measures (Comité International des Poids et Mesures: CIPM), which in turn has created advisory committees (comités consultatifs) covering specific fields of physical measurement. The Advisory Committee on Photometry (CCP) met in Paris in September to review the development of photometric standards over the last 6 years and to discuss the advisability of various types of activity in the future.

The final recommendations of this committee, of which NBS is a member, should interest workers in radiometry and photometry because they all indicate a strong desire for development both of radiometry and of photometry in such a way

that the two fields will become more strongly coupled. A summary of these recommendations is as follows:

1) The melting point of platinum should be remeasured in several laboratories in order to couple radiometry and photometry more reliably.

2) Work of the type performed recently at the National Physical Laboratory (NPL; Great Britain) with a new platinum melting point blackbody and a new "blackbody" lamp should be encouraged.

3) The suitability of radiometrically oriented photometric systems should be studied in detail. Two examples of such systems are those based on (1) spectroradiometry and (2) suitably filtered, electrically calibrated detection.

4) The coupling between radiometric and photometric units should be strengthened.

5) Because of the great difficulty and increasing importance of both spectral and total radiometric measurements, radiometry should be considered at least as important as photometry in the work of the CCP and the name of the committee should be changed to the "Advisory Committee for Photometry and Radiometry" (Comité Consultatif de Photométrie et de Radiométrie: CCPR).

The week after the CCP meeting in Paris the CIE met in Barcelona. The CIE concerns itself with the application of the basic unit system to practical optical radiation measurement problems. Because of the

diversity of these problems, various technical committees have been established to take responsibility for the establishment of uniform and compatible practice in a number of areas of radiation measurement, the utilization of it for various purposes, and its effects on the environment. At the recent meeting the CIE committee on photometry, E-1.2, reviewed its work of the last 4 years. This work consisted of:

1) The preparation, under the leadership of C. L. Sanders of the National Research Council of Canada (NRC), of a comprehensive document on the fundamental basis of photometry, "Principles of Light Measurements," CIE Publication No. 18 (E-1.2) 1970.

2) Another document in the final stages of completion: "Procedures for the measurement of luminous flux of discharge lamps and for their calibration as working standards" prepared under the leadership of O. C. Jones of NPL.

The former document is now available and the latter will shortly be available from the CIE U.S. National Committee, H. K. Hammond III, Secretary, NBS, Washington, D.C. 20234, or from the international office: Bureau Central, 4, avenue du Recteur Poincaré, Paris 16<sup>e</sup>, France. CIE No. 18 costs \$6, postpaid, when ordered from the U.S. National Committee. We shall be very interested to learn from our readers whether or not these documents prove useful either for general education or for



solving specific problems encountered in the laboratory.

The rest of the work of the committee E-1.2 has centered on the following intercomparisons:

3) A comparison of the measurement of the relative spectral response of vacuum photodiodes mounted with auxiliary paraphernalia, organized by H. W. Budde of NRC. Although the interpretation of the results is complicated by drift in the response of some of the diodes, a description of the results will be published when those laboratories wishing to repeat their measurements have done so.

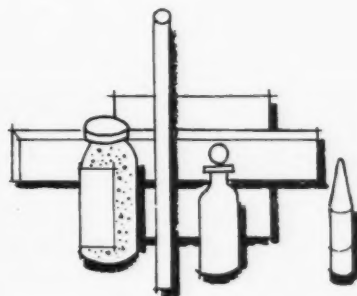
4) A comparison of reflectance measurements of opal glass and barium sulfate organized by Mme.

Kartachevskaja of the Institute of Metrology (IMM; Soviet Union). The challenge in this intercomparison results from the facts that, while opal glass is relatively stable, it is a distinctly imperfect diffuser; and barium sulfate, while a good diffuser, is relatively unstable on transportation.

5) An intercomparison of the relative spectral irradiance of fluorescent and tungsten halogen lamps organized by C. L. Sanders of NRC. A particularly interesting feature of this work was an experiment involving systematic variation of a number of parameters at NRC. Dr. Sanders expects to use the results of this intercomparison and his experiments to produce a rec-

ommended procedure for the measurement of spectral irradiance with a spectroradiometer.

With the anticipated completion of these various projects over the next 2 years, a turning point will be reached in the future activity of Committee E-1.2. The past emphasis on the group preparation of documents and intercomparison will very likely decrease. What will take their place is yet to be determined; but an increase in direct communication among laboratories, particularly with an emphasis on the determination of services for industry, is anticipated. Comment from our readers on the most urgent activity for this committee is solicited.



#### **PHOTOGRAPHIC STEP TABLETS ISSUED AS STANDARD REFERENCE MATERIAL**

Photographic step tablets are now being issued as Standard Reference Materials.<sup>1</sup> The new procedure was initiated to provide a central source of calibrated step tablets for use in calibrating densitometers, microdensitometers, and x-ray equipment; in sensitometry; in determining exposure of photographic material; and in quality control of film processing. Previously the Bureau had calibrated step tablets submitted by users. This arrangement was far from satisfactory, however, as the tablets were often not suffi-

ciently uniform for precise measurements, or had been degraded by dirt, fingerprints, or scratches before they reached the Bureau.

The step tablets, SRM 1009, are designated as Type Visual VI-b and are certified for diffuse transmission density in conformance with conditions specified for American National Standard Diffuse Visual Density, Type VI-b "ANSI PH2.19-1959." The step tablets are  $3.5 \times 25$  centimeters, having 21 steps of density ranging from 0 to 3. They are individually certified by a method having a precision such that three times the standard deviation of the mean is 1 percent or 0.01, whichever is greater.

SRM 1009 may be obtained from the Office of Standard Reference Materials, Room B314, Chemistry Building, National Bureau of Standards, Washington, D.C. 20234. The price is \$54 per step tablet.

Those users who have valid need for special calibrations should write or call:

William Smallwood  
Room B214, Metrology Building  
National Bureau of Standards  
Washington, D.C. 20234  
(Telephone: (301) 921-2157)

<sup>1</sup> For a complete list of Standard Reference Materials available from the National Bureau of Standards, see Catalog of Standard Reference Materials, NBS Special Publication 260 (July 1970 Ed.) for sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 for 75 cents.



# NEWS

*The NSRDS was established to make critically evaluated data in the physical sciences available to science and technology on a national basis. The NSRDS is administered and coordinated by the NBS Office of Standard Reference Data.*

## SECOND EDITION, JANAF THERMOCHEMICAL TABLES

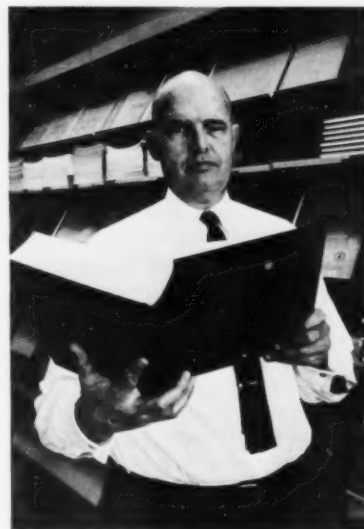
The Joint Army-Navy-Air Force (JANAF) Thermochemical Tables project was established in late 1959 at the Dow Thermal Research Laboratory, Midland, Mich., under the direction of Daniel R. Stull. The purpose of the project originally was to compile and publish consistent tables of thermodynamic data required for rocket propellant performance calculations. A related experimental program carried on in a number of laboratories provided missing data and redetermination of questionable values. Technical advice and guidance have been provided by a group of consultants from government, universities, and industry. In 1969, Harold Prophet succeeded D. R. Stull as the Project Director.

JANAF Thermochemical Tables project covers thermodynamic properties over a wide range in the solid, liquid, and ideal gaseous state. Included are the following elements: Al, B, Be, Br, C, Cl, Co, Cu, F, Fe, H, Hg, I, K, Li, Mg, Mo, N, Na, O, P, Pb, S, Si, Ti, W, Zr, and their simple compounds. These compounds are principally those with the halogens, oxygen, and hydrogen; in all about 1100 chemi-

cal species are covered in the Second Edition. The properties given are heat capacity, entropy, Gibbs energy function, enthalpy, heat of formation, and Gibbs energy of formation for the ideal gas, liquid, or solid state. The logarithm of equilibrium constant of formation of each compound from the elements in their standard reference states is also given. The foregoing properties are tabulated at 100° intervals from 0 K to an appropriate upper limit (6000 K in the case of the ideal gas state). Each table is accompanied by a list of the input data, including standard-state thermodynamic properties, molecular weight, point group, ground state configuration, vibrational frequencies and degeneracies, bond distances and angles, and product of the moments of inertia. Sources of data consist of the open literature and, to some extent, private communications; selected references are cited. Empirical or quasi-theoretical computations, and estimates obtained by various means are used to supply data not available from other sources. An effort has been made to maintain internal consistency.

The first bound edition of the *JANAF Thermochemical Tables* was published in 1965. Three addendums followed very closely in 1966, 1967, and 1968. Though sponsored and monitored by agencies of the Defense Department, the JANAF Thermochemical Tables Project has been considered an important part of the National Standard Reference Data System. The

Tables have found wide use in technical areas far removed from those for which the work was initiated. Consequently, when plans for a second edition of the *JANAF Thermochemical Tables* were under discussion, a suggestion was made that they be incorporated into the NSRDS-NBS publications series. The Office of Standard Reference Data readily accepted this suggestion and the present volume, NSRDS-NBS 37, *JANAF Ther-*



*Dr. H. J. White, Jr., Program Manager, Thermodynamic and Transport Properties, NBS Office of Standard Reference Data, scans through the Second Edition, Joint Army-Navy-Air Force (JANAF) Thermochemical Tables, which is the latest addition to the NBS-NSRDS publications. Other NBS-NSRDS publications can be seen in the background.*

mochemical Tables, Second Edition<sup>1</sup> (SD Catalog No. C13.48:37, \$9.75) was the result.

#### **CRITICAL REVIEW OF ULTRAVIOLET PHOTOABSORPTION CROSS SECTIONS FOR MOLECULES OF ASTROPHYSICAL AND AERONOMIC INTEREST**

NSRDS-NBS 38, *Critical Review of Ultraviolet Photoabsorption Cross Sections for Molecules of Astrophysical and Aeronomic Interest*<sup>1</sup> (SD Catalog No. C13.48:38, \$1) by R. D. Hudson is a critical review covering ultraviolet absorption by atoms and simple molecules in the wavelength region under 3000 Å. It contains a discussion of the relative merits of various experimental techniques along with possible systematic and random errors that may be associated with each. The problems in data analysis associated with finite spectral bandwidths are reviewed. Special emphasis is given in the review to the interpretation of published absorption cross sections. Figures are provided to enable a comparison of the results of several determinations as well as to point out where difficulties of interpretation might arise. The intention of this review is to make a critical analysis of the available cross-section data, to assess their reliability and to give the reader an idea of the limitations that must be placed on the interpretation and use of these data. The author provides a list of references at the end of the review of those papers that, in his opinion, contain the more reliable data.

#### **EDITORIAL BOARD, JOURNAL OF PHYSICAL AND CHEMICAL REFERENCE DATA**

The Editorial Board for the *Journal of Physical and Chemical Reference Data*, which will begin in 1972 to publish quarterly the output of the National Standard Reference Data System, has been announced as follows:

Representing NBS are David R. Lide, Jr., Office of Standard Reference Data, Editor; Lee J. Kieffer, Joint Institute for Laboratory Astrophysics; John B. Wachtman, Jr., Inorganic Materials Division; and Howard J. White, Jr., Office of Standard Reference Data.

Representing the American Institute of Physics are S. A. Goudsmit, Brookhaven National Laboratory; R. Bruce Lindsey, Brown University; D. L. MacAdam, American Institute of Physics.

Representing the American Chemical Society are Bruce H. Sage; Daniel R. Stull, Dow Chemical Company; Bruno J. Zwolinski, Texas A&M University.

The following subscription rates for the *Journal of Physical and Chemical Reference Data* have been established:

U.S. Members of the AIP and ACS \$20,

Foreign Members of the AIP and ACS \$23,

Nonmembers, in U.S. \$60,

Nonmembers, Foreign \$63.

All subscriptions should be sent to the American Chemical Society, 1155 16th Street, N.W., Washington, D.C. 20036.

#### **TRANSLATION OF CRITICAL REVIEW FROM THE U.S.S.R.**

*Electric Conductivity of Ferroelectrics* by V. M. Gurevich (\$3), a publication from the U.S.S.R. Committee of Standards, Measures and Measuring Instruments, in the series initiated by GSSSD (State Service for Standard and Reference Data) is a critical review which has been translated and published for the U.S. Department of Commerce and the National Science Foundation. This reference book contains information on the electrical conductivity and some other properties of 60 compounds, 58 solids solutions, and 10 ferroelectric ceramics which have ferroelectric (or antiferroelectric) properties. The

author discusses examples of practical application of some conductivity effects of ferroelectrics and describes the equipment or processes for these effects. Included in the discussion are: conductivity in relation to properties of ferroelectrics; the physical bases of the conductivity measurements; the nature and mechanism of intrinsic and impurity conductivity; the effect of aging on conductivity; the nature of dielectric losses and breakdown; and the conductivity anomaly in the region of ferroelectric phase transitions. The author's evaluation procedures and approach are also presented in this review. This translation may be ordered under the number TT 70-50180 for the price indicated from the National Technical Information Service, Springfield, Va. 22151.

#### **TWO NEW CERN COMPILATIONS AVAILABLE**

Two new compilations in the area of high energy physics from CERN, the European Organization for Nuclear Research, Geneva, Switzerland, are available to interested users in the Western Hemisphere and the Far East by writing to the Lawrence Radiation Laboratory, Berkeley, Calif. 94720.

CERN/HERA 70-6, Oct. 1970, *Compilation of Cross Sections V—K<sup>+</sup> Induced Reactions*, by E. Flaminio, J. D. Hansen, D. R. O. Morrison and N. Tovey is a compilation of cross sections of reactions produced by negative kaons on targets of protons, neutrons, and deuterons. Graphs of the variation of cross section with incident laboratory momentum are plotted. Values for the rate of decrease of cross section with incident momentum are provided.

CERN/HERA 70-7, Oct. 1970, *Compilation of Cross Sections VI— $\pi^-$  Induced Reactions*, by E. Flaminio, J. D. Hansen, D. R. O. Morrison and N. Tovey is a similar compilation of cross sections of

reactions produced by negative pions on targets of protons, neutrons, and deuterons.

### THERMOPHYSICAL PROPERTIES OF OXYGEN

During the last 10 years, oxygen has increased more in commercial importance than any other cryogenic fluid. Along with this growth in applications has come the need for more data on oxygen, which is of wider scope and greater variety. To meet this need NBS Technical Note 384, *Thermophysical Properties of Oxygen from the Freezing Liquid Line to 600 R for Pressures to 5000 psia*

by Robert D. McCarty and Lloyd A. Weber<sup>1</sup> (\$1.50, SD Catalog No. C13.46:384), was compiled on the properties of oxygen commonly used for engineering calculations. The values presented have been critically evaluated by the authors and represent the "best values" available at this time.

The tables include entropy, enthalpy, internal energy, density, volume, speed of sound, specific heat, thermal conductivity, viscosity, thermal diffusivity, Prandtl number and the dielectric constant for 79 isobars. Also included in the isobaric tables are quantities of special utility in heat transfer calcula-

tions:  $(\partial P/\partial V)_T$ ,  $(\partial P/\partial T)_P$ ,  $V(\partial H/\partial V)_P$ ,  $V(\partial P/\partial U)_T$ ,  $-V(\partial P/\partial V)_T$ ,  $1/V(\partial V/\partial T)_P$ .

In addition to the isobaric tables, tables for the saturated vapor and liquid are given which include all of the above properties, plus the surface tension. Tables for the P-T of the freezing liquid, index of refraction and derived Joule-Thomson inversion curve are also presented. The specific heat of the saturated liquid is given in graphical form. A temperature-entropy chart and a Mollier diagram are also included.

<sup>1</sup> Order by SD Catalog Number from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for the price indicated.

## PUBLICATIONS of the National Bureau of Standards\*

### PERIODICALS

*Technical News Bulletin*, Annual subscription: Domestic, \$3; foreign, \$4. Single copy price 30 cents. Available on a 1-, 2- or 3-year subscription basis. SD Catalog No. C13.13:55.

*Journal of Research of the National Bureau of Standards*

*Section A. Physics and Chemistry*. Issued six times a year. Annual subscription: Domestic, \$9.50; foreign, \$11.75. Single copy price varies. SD Catalog No. C13.22/sec.A:74.

*Section B. Mathematical Sciences*. Issued quarterly. Annual subscription: Domestic, \$5; foreign, \$6.25. Single copy, \$1.25. SD Catalog No. C13.22/sec.B:74.

*Section C. Engineering and Instrumentation*. Issued quarterly. Annual subscription: Domestic, \$5; foreign, \$6.25. Single copy, \$1.25. SD Catalog No. C13.22/sec.C:74.

### OTHER NBS PUBLICATIONS

Baker, M. A., 1939 exposure test of porcelain enamels on steel 30-year inspection. Nat. Bur. Stand. (U.S.), Bldg., Sci. Ser. 38, 9 pages (Aug. 1971) 25 cents, SD Catalog No. C13.29/2:38.

Breden, L. H., Technical Standards Coordinator, Fluorinated ethylenepropylene (FEP) plastic tubing. Nat. Bur. Stand. (U.S.), Prod. Stand. 43-71, 12 pages (Sept. 1971) 10 cents, SD Catalog No. C13.20/2:43-71.

Devereux, C. W., Technical Standards Coordinator, Body measurements for the sizing of women's patterns and apparel. Nat. Bur. Stand. (U.S.), Prod. Stand. 42-70, 29 pages (Sept. 1971) 40 cents, SD Catalog No. C13.20/42-70.

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# Technical News Bulletin

Vol. 55, 1971

## A-B

A Metric America (Sept.)	222
Absorbed Dose, New Calorimetric Standard of (May)	115
Accelerometers, Computer Automates Calibration of (Nov.)	264
Accurate Measurements of Josephson Junction Voltage (Jan.)	3
Accurate Mercury Manometer for the NBS Gas Thermometer, An (Mar.)	73
Accurate Vapor Pressure Equation for Water (Nov.)	269
Acoustic Formulas Predict Propagation Instability (Apr.)	108
Additional Interlaboratory Programs for Rubber (Apr.)	107
Affluent Society, Product Performance in an (July)	165
Air Pollution Samplers, Siting (Nov.)	278
Air Traffic Control System, Computer Simulation of (June)	148
Amalgam Condensation Questioned, Safety of Ultrasonic (Sept.)	212
Assistant Secretary, Wakelin Named (July)	171
Atomic Weights, Coulometric Determination of (Nov.)	263
Auroral Displays, The Electron's Role in (June)	155
Automobile Seatbelt Anchorages Surveyed (Feb.)	35
Awards Presented, Stratton and Rosa (July)	170
Base Units, Philosophical Basis for (Mar.)	64
Brake Fluid, Research on Hydraulic (Feb.)	36
Brake Stopping Power, Measuring (July)	172
Breakthrough Housing Unit Undergoes Evaluation (May)	124
Bridge Collapse, Point Pleasant (Aug.)	196
Bridge Compensates for Lead Impedance (July)	163

## C-D

Calorimeter for Laser Energy Measurement, Solid State (Feb.)	45
Calorimetric Standard of Absorbed Dose, New (May)	115
Cassette Program Initiated, Magnetic Tape (Apr.)	107
Commerce Bill Would Promote Exports (July)	171
Computer at NBS Reactor, Time-Sharing (Jan.)	9
Computer Automates Calibration of Accelerometers (Nov.)	264
Computer Program Manipulates and Plots Data (Feb.)	44
Computer Program Selects Charts and Plots Data (Sept.)	214
Computer Rooms Downtown (June)	139
Computer Simulation of Air Traffic Control System (June)	148
Computers, Machine Reads Oceanographic Data for (June)	145

## CONFERENCES

Accuracy in Spectrophotometry and Luminescence Measurements (Nov.)	109
ACM Symposium (Apr.)	83
Analytical Chemistry (Mar.)	28
Calorimetry Conference, 55th Annual (Jan.)	83
Computers for Environment Engineering, Use of (Mar.)	109
Fifth Materials Research Symposium (Apr.)	252
Joint Measurement Conference (Oct.)	134
Space Simulation (May)	252
Thirteenth Scintillation and Semiconductor Conference (Oct.)	158
Weights and Measures, 56th National Conference on (June)	5
Consumer Information Series, New NBS (Jan.)	247
Copper Study, INCRA Funds (Oct.)	263
Coulometric Determination of Atomic Weights (Nov.)	245
Crystal Filter Narrows, Stabilizes Dye Laser Output (Oct.)	248
Defects in Wire Bonds (Oct.)	117
Design Package Available for NBS RF Power Measurement System (May)	48
Development of Voluntary Product Standards (Feb.)	300
Directional Coupler Design Extends Performance (Dec.)	243
Dissociation of Gases by Electron Bombardment (Oct.)	187
Downed Fliers, Locator-Beacon Research Aids (Aug.)	

## E-F

Ecologists, Polarography—A Tool for (Aug.)	192
Effects of Pressure on Glass Fracture (June)	147
Electrical Feedthrough for High Pressures, Simple Dependable (Mar.)	85
Electrodes, Standardization of Ion-Selective (Jan.)	4
Electron's Role in Auroral Displays, The (June)	155
Exports, Commerce Bill Would Promote (July)	171
Exports Through International Standardization, Proposed Bill to Promote (July)	171
Fabric Flammability Test Anomaly Resolved (June)	140

## FEDERAL INFORMATION PROCESSING STANDARDS NOTES

ADP Product Information Resources (Jan.)	25
ADP Software Information Resources (May)	126
ANSI Bank Check Standards (May)	127
COBOL Receives ISO Approval (May)	127
Conference on Management of Computer Systems (Feb.)	55
Display Control Functions (Sept.)	215
ECMA (Mar.)	76
Graphic Representations for ASCII Control Characters (Jan.)	26
Guidelines for Proposals to ANSI X3 (June)	150
ISO Standardization Terms (Aug.)	203
Machine Sensible Data Files Available (May)	128
Management of Information and Knowledge (Jan.)	27
New Congressional Atlas (May)	128
New ISO President (Jan.)	125
Numeric Date-Writing Code Adopted (May)	126
OMB Assigned FIPS Approval Authority (Sept.)	217
Proposed Standard for Representing SI Units (July)	179
Revision to OCR Standard (May)	128
Soft Copy Conference (Sept.)	215
Standard for Numbering Weeks (May)	127
Task Group for Describing Data Interchange Formats (Mar.)	78
Task Groups on COBOL and Computer Performance (Aug.)	203
Telecommunication Standards (Apr.)	93
Vocabulary for Information Processing (Jan.)	25
Field Emission, Hot-Hole Electron Cascades in (Oct.)	239
Film Breakdown Studied, Passive (May)	121
First Evidence of Promethium in a Star (Nov.)	283
First Metric Study Report Features International Standards (Mar.)	69
Fixed Points, Superconductive Transitions Suitable for Thermometric (Feb.)	39
Flammability Test Anomaly Resolved, Fabric (June)	140
Fluorescence Yields Measured for Light Elements (Apr.)	102
Fluorescent Lamps, Intercomparison of (Aug.)	199
Fortran Program Assures Computational Accuracy (Oct.)	242
Fringe Counting Ultrasonic Interferometer (Aug.)	195
Future of International Standards, The (Feb.)	40

## G-H-I-J

Gamma-Ray Source Handling System (Aug.)	188
Glass Thermometer, An Accurate Mercury Manometer for the NBS (Mar.)	73
Glass Fracture, Effect of Pressure on (June)	147
Glass, Surface Damage of Laser Exposed (Sept.)	213
Heartbeat, Superconducting Device Measures Magnetically (Apr.)	100
Heated-Air Adiabatic Saturation Psychrometer (June)	154
High Pressures, Simple Dependable Electrical Feedthrough for (Mar.)	85
Hot-Hole Electron Cascades in Field Emission (Oct.)	239
Housing Unit Undergoes Evaluation, Breakthrough (May)	124
Hydraulic Brake Fluids, Research on (Feb.)	36
Hydrogen Frequency Measured Accurately (Aug.)	194
Improved Sliding Short Eases Microwave Measurements (Jan.)	17
Improved Technique for Polymer Film Measurements (Feb.)	38
INCRA Funds Copper Study (Oct.)	247
Industry's Response to New-State-Standards Program, An (Dec.)	298
Intercomparison of Fluorescent Lamps (Aug.)	199
Interferograms of Variable Visibility, Near Perfect (May)	129
Interferometer, Fringe Counting Ultrasonic (Aug.)	195
International Standardization, Proposed Bill to Promote Exports Through (July)	171
International Standards, First Metric Study Report Features (Mar.)	69
International Standards, The Future of (Feb.)	40
Inventions, Patents Granted on NBS (Jan.)	6
Ion-Selective Electrodes, Standardization of (Jan.)	4
Josephson Junction Voltage, Accurate Measurements of (Jan.)	3

## L-M

Laser Energy Measurement, Solid State Calorimeter for (Feb.)	45
Laser Exposed Glass, Surface Damage of (Sept.)	213
Laser Safety Measurements, System Aids (May)	122
Lead Impedance, Bridge Compensates for (July)	163
Light Elements, Fluorescent Yields Measured for (Apr.)	102

Lithium Vapor Spectra Investigated (Mar.).....	63
Locator-Beacon Research Aids Downed Fliers (Aug.).....	187
Low Temperatures and High Magnetic Fields; Magnetometer for Use at Very (Apr.)...	92
Machine Errors Measured, Universal Testing (Apr.).....	103
Machine Reads Oceanographic Data for Computers (June).....	145
Magnetic and Optical Studies of Ruby (Apr.).....	91
Magnetic Tape Cassette Program Initiated (Apr.).....	107
Magnetometer for Use at Very Low Temperatures and High Magnetic Fields (Apr.)...	92
Manometer for the NBS Gas Thermometer, An Accurate Mercury (Mar.).....	73
Measurement Seminars 1971-1972 Series (Oct.).....	246
Measurement Standards, Language of Discovery (Jan.).....	12
Measuring Brake Stopping Power (July).....	172
Membrane Roofing Research Project (Jan.).....	16
Metals, Surface States of Electrons in (June).....	153
Metric America, A (Sept.).....	222
Metric Study Report Features International Standards, First (Mar.).....	69
Microwave Measurements, Improved Sliding Short Eases (Jan.).....	17
Mine Safety, NBS Asked to Aid (May).....	130
MIT Group, NBS Cooperates with (Jan.).....	21

## N

### NATIONAL STANDARD REFERENCE DATA SYSTEM NEWS

ASTM Data Series (July).....	177
Atomic Ultraviolet Photoabsorption Cross Sections (Sept.).....	218
Bibliography of Atomic and Molecular Processes (May).....	132
Bibliography on Defect Centers in Alkali Halides (Aug.).....	201
Bimolecular Gas Reactions (May).....	132
CERN Compilations (July).....	176
Chemical Kinetics Survey (Apr.).....	97
Critical Micelle Concentrations (July).....	176
Cryogenic Data Center (Apr.).....	96
Discussion on State of Transport Data (Nov.).....	284
Editorial Board for the Journal of Physical and Chemical Reference Data (Dec.)...	307
Formula Designations of Chemical Compounds (Aug.).....	200
Hardness Data (Sept.).....	220
High Temperature Reaction Data (July).....	177
Informalogia Yugoslavica (Sept.).....	220
Ionization Potentials and Limits (Feb.).....	52
JANAF Thermochemical Tables (Dec.).....	306
Journal of Physical and Chemical Reference Data (Nov.).....	284
Key Values for Thermodynamics (Jan.).....	22
List of Neutron Cross Section Compilations (May).....	132
Magnetic Tape for Text Editing (May).....	131
Methods for Formula Designation (July).....	177
New Publication Arrangement (Sept.).....	218
NN and NO Interactions (Apr.).....	98
Numerical Data Advisory Board Membership (Oct.).....	254
Organized Evaluation of Rate Data (Mar.).....	80
Proton Induced Reactions (May).....	133
Reference Works for the Chemical Kineticist (June).....	142
Selected Tables of Atomic Spectra (Nov.).....	284
SFCSI List of Translations (Feb.).....	54
Sixth Annual Meeting of CODATA (Oct.).....	254
Standard X-Ray Diffraction Powder Patterns (Feb.).....	53
Survey of Electrical Resistivity (Feb.).....	53
Symposium on Data Evaluation (May).....	132
Tables of Atomic Spectra (Apr.).....	97
Thermal Conductivity Award (Feb.).....	54
Thermodynamic Properties of Fluorine (Feb.).....	53
Thermodynamics Research Center (Oct.).....	255
Thermophysical Properties of Matter (Sept.).....	219
Thermophysical Properties of Oxygen (Dec.).....	308
Third Edition of Crystal Data, Determinative Tables (Nov.).....	286
Translation of Critical Review from the U.S.S.R. (Dec.).....	307
Translation of Electric Conductivity of Ferroelectrics (Dec.).....	307
Translations of U.S.S.R. Data Compilations (Aug.).....	201
Two New CERN Compilations (Dec.).....	307
U.S. National Committee for CODATA (Oct.).....	255
Ultraviolet Photoabsorption Cross Sections (Dec.).....	307
NBS Asked to Aid Mine Safety (May).....	130
NBS Cooperates with MIT Group (Jan.).....	21
NBS Makes its First Measurements of Transition Probabilities in VUV (Apr.).....	110
NBS Workshop (Aug.).....	Insert
Near Perfect Interferograms of Variable Visibility (May).....	129
Neutron Activation Analysis (Aug.).....	190
New ASTM Section on Microelectric Bonding (Oct.).....	251
New Calorimetric Standard of Absorbed Dose (May).....	115
New Method of Thermal Analysis Measures Products Not Reactants (Feb.).....	43
New NBS Consumer Information Series (Jan.).....	5
New Sulfur Dioxide Permeation Tube (Apr.).....	106
1972 W. D. George Memorial Award (Oct.).....	241
Nuclear Models Are Correlated, Two (May).....	116

## O-P

Oceanographic Data for Computers, Machine Reads (June).....	145
Optical Radiation News (Oct.).....	256
Oversized Tools for Ultrasonic Machining (July).....	164
Panic Stops: Are Women Strong Enough? (Jan.).....	15
Passive Film Breakdown Studied (May).....	121
Patents Granted on NBS Inventions (Jan.).....	6
Physical Constants, Revised List of (Mar.).....	71
Piezoelectric Effect in Polymers (Oct.).....	240
Point Pleasant Bridge Collapse (Aug.).....	196
Polarography - A Tool for Ecologists (Aug.).....	192
Policy for NBS Usage of SI Units (Jan.).....	10
Polymer Film Measurements, Improved Technique for (Feb.).....	38
Polymers, Piezoelectric Effect in (Oct.).....	240
Postdoctoral Research Associates Named (Aug.).....	207
Postdoctoral Research Associateship for 1972 (Nov.).....	277
Precision Measurement Grants (Nov.).....	282
Predicting Tire Tread Life (June).....	14
Product Performance in an Affluent Society (July).....	165
Promethium in a Star, First Evidence of (Nov.).....	283
Propagation Instability, Acoustic Formulas Predict (Apr.).....	108
Proposed Bill to Promote Exports Through International Standardization (July).....	171
Psychrometer, Heated-Air Adiabatic Saturation (June).....	154

### PUBLICATIONS

Building Research at NBS (Feb.).....	51
Compressive Strength of Masonry Walls (May).....	134
Current Symbols and Terminology in the Fields of Radiation, Light, and Color (Feb.).....	51
Electromagnetic Metrology Current Awareness Service (Feb.).....	50
Eleven Ways to Reduce Energy Consumption in Household Cooling (Oct.).....	252
Hearing Aids (May).....	134
Index to Selected Statistical Journals (Jan.).....	28
Innovative Metrology (June).....	158
NTIS Sales Desk (Mar.).....	84
Nuclear Instrument Module System (Feb.).....	50
Photonuclear Reactions (Jan.).....	29
Portland Cement Pastes and Motors (Jan.).....	28
Precision Measurement and Calibration: Electricity-Radio Frequency (Jan.).....	29
Publications of NBS 1968-69 (Apr.).....	110
Radiological Safety for Accelerators (Jan.).....	30
Seven Ways to Reduce Fuel Consumption in Heating (Mar.).....	84
Technical Highlights, 1970 (Apr.).....	109

## R

Railway Test Cars Renovated (May).....	118
Reactor, Time Sharing Computer at (Jan.).....	9
Red Shifts, White Dwarfs, and the Stark Effect (Sept.).....	211
Research on Hydraulic Brake (Feb.).....	36
Revised List of Physical Constants (Mar.).....	71
RF Power Measurement System, Design Package Available for (May).....	117
Research Project, Membrane (Jan.).....	16
Rosa and Stratton Awards, 1970 (Jan.).....	30
Rosa and Stratton Awards Presented (July).....	170
Rubber, Additional Interlaboratory Programs for (Apr.).....	107
Ruby, Magnetic and Optical Studies of (Apr.).....	91

## S

Safety of Ultrasonic Amalgam Condensation Questioned (Sept.).....	212
Seatbelt Anchorages Surveyed, Automobile (Feb.).....	35
Seatbelts, Strength of Used (Aug.).....	198
Secondary Wavelength Standard, Thorium Spectrum Proposed as Improved (Jan.)...	8
SI Units: Philosophical Basis for the Base Units (Mar.).....	64
SI Units, Policy for NBS Usage of (Jan.).....	18
Simple Dependable Electrical Feedthrough for High Pressures (Mar.).....	85
Siped Tires No Advantage on Wet Roads (Oct.).....	244
Siting Air Pollution Samplers (Nov.).....	278
Solid State Calorimeter for Laser Energy Measurement (Feb.).....	45
NATIONAL STANDARD REFERENCE MATERIALS	
Alumina (Sept.).....	232
Austenite in Ferrite (Apr.).....	104
Borax (Sept.).....	233
Cadmium and Silver Vapor Pressure Standards (Jan.).....	12
Certified Gas Standards (Jan.).....	11
D-glucose (Apr.).....	105
High Temperature Alloys (Apr.).....	105
Iron and Magnesium for Petroleum (Sept.).....	232
Iron Carbide in Ferrite (Apr.).....	104
Microanalysis Standards (Apr.).....	105
Orchard Leaves (Sept.).....	231

144

OFFICIAL BUSINESS

POSTAGE AND FEES PAID  
U.S. GOVERNMENT PRINTING OFFICE



Photographic Step Tablet (Dec.)	305	System Aids Laser Safety Measurements (May)	122
Plutonium (Sept.)	232	Systems Analysis Aids in Urban Problem Areas (Dec.)	296
Potassium Dichromate (Sept.)	233		
Rhodium Chloride (Sept.)	232		
Sapphire (Apr.)	104		
Thermal Analysis SRM's (Sept.)	232		
Tri-(Hydroxymethyl) Aminoethane (Apr.)	105	Telephone Cable Shields, Underground (May)	123
Standardization of Ion-Selective Electrodes (Jan.)	4	Temperature Distribution on Transistor Surfaces (July)	182
		Ten-Ten-Repeaters, Railway (May)	118

## 1

Standard Frequency and Time Broadcasts		Thorium Spectrum Proposed as Improved Secondary Wavelength Standard (Jan.)...	79
(Jan.).....	47	Time Scale to Change in 1972, UTC (Mar.).....	8
(Feb.).....	47	Time-Sharing Computer at NBS Reactor (Jan.).....	9
(Mar.).....	84	Tire Tread Life, Predicting (June).....	141
(Apr.).....	98	Tools for Ultrasonic Machining, Oversized (July).....	164
(May).....	135	Transistor Surfaces, Temperature Distribution on (July).....	182
(June).....	157	Transition Elements, Synthesis of Organo-Derivatives (Dec.).....	292
(July).....	175	Transition Probabilities in VUV, NBS Makes its First Measurements of (Apr.).....	110
(Aug.).....	206	Trowbridge, Roy, ANSI President (June).....	157
(Sept.).....	220	Two Nuclear Models Are Correlated (May).....	116
(Oct.).....	258		
(Nov.).....	279		
Broadcast of New Time Scale (Feb.).....	47		
First Day QSL Card (July).....	175		
Microphone Calibration Service (May).....	135	Ultrasonic Amalgam Condensation Questioned, Safety of (Sept.).....	215
New Calibration Service for the Volt (Feb.).....	46	Ultrasonic Interferometer, Fringe Counting (Aug.).....	192
New Program Format (Apr.).....	98	Ultrasonic Machining, Oversized Tools for (July).....	164
Time Signals on Telephone (Sept.).....	221	Underground Telephone Cable Shields (May).....	123
Stark Effect, Red Shifts, White Dwarfs, and the (Sept.).....	211	Universal Testing Machine Errors Measured (Apr.).....	103
Steel Pillings in Soils (May).....	120	Urban Problems Areas, Systems Analysis Aids in (Dec.).....	296
Stratton and Rosa Awards, 1970 (Jan.).....	30	UTC Time Scale to Change in 1972 (Mar.).....	79
Stratton and Rosa Awards Presented (July).....	170	Voluntary Product Standards, Development of (Feb.).....	110
Strength of Used Seatbelts (Aug.).....	198	VUV, NBS Makes its First Measurements of Transition Probabilities in (Apr.).....	48
Sulfur Dioxide Permeation Tube, New (Apr.).....	106	Wakelin Named Assistant Secretary (July).....	171
Superconducting Device Measures Heartbeat Magnetically (Apr.).....	100	Water, Accurate Vapor Pressure Equation for (Nov.).....	265
Superconducting Transitions Suitable for Thermometric Fixed Points (Feb.).....	39	Wavelength Standard, Thorium Proposed as Improved Secondary (Jan.).....	8
Surface Damage of Laser Exposed Glass (Sept.).....	213	Wet Roads, Siped Tires No Advantage on (Oct.).....	248
Surface States of Electrons in Metals (June).....	153	White Dwarfs, and the Stark Effect, Red Shifts (Sept.).....	211
Synchrotron Used to Calibrate NASA Detector (Nov.).....	292	Wire Bonds, Defects in (Oct.).....	241
Synthesis of Organo-Derivatives of Transition Elements (Dec.).....	276	Women Strong Enough?, Panic Stops: Are (Jan.).....	15
		World's Largest Testing Machine Goes into Operation (Nov.).....	27

## U-V-W

175	Ultrasonic Amalgam Condensation Questioned, Safety of (Sept.)	212
135	Ultrasonic Interferometer, Fringe Counting (Aug.)	195
46	Ultrasonic Machining, Oversized Tools for (July)	164
98	Underground Telephone Cable Shields (May)	123
221	Universal Testing Machine Errors Measured (Apr.)	103
211	Urban Problems Areas, Systems Analysis Aids in (Dec.)	296
120	UTC Time Scale to Change in 1972 (Mar.)	79
30	Voluntary Product Standards, Development of (Feb.)	48
170	VUV, NBS Makes its First Measurements of Transition Probabilities in (Apr.)	110
198	Wakelin Named Assistant Secretary (July)	171
106	Water, Accurate Vapor Pressure Equation for (Nov.)	269
100	Wavelength Standard, Thorium Proposed as Improved Secondary (Jan.)	8
39	Wet Roads, Siped Tires No Advantage on (Oct.)	244
213	White Dwarfs, and the Stark Effect, Red Shifts (Sept.)	211
153	Wire Bonds, Defects in (Oct.)	248
276	Women Strong Enough?, Panic Drops: Are (Jan.)	15
292	World's Largest Testing Machine Goes into Operation (Nov.)	274



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